PLACENTA SCANNING WITH ^{113m}In

Roger D. Niehoff, William R. Hendee and Donald W. Brown

University of Colorado Medical Center, Denver, Colorado

Many methods of placenta localization have been used to diagnose placenta previa, marginal placenta and other causes of third trimester bleeding. These include ultrasound (*1*), thermography (*2*), soft-tissue roentgenography both with and without contrast agents (*3*) and radioisotope placentography (*4–8*). The last method has been refined to nearly 100% accuracy by the use of recently introduced nuclides and newer scanning techniques. Radiopharmaceuticals that have been used include ^{24}Na ion, human serum albumin tagged with ^{51}Cr, ^{131}I, ^{132}I and ^{99m}Tc (*9*), RBCs labeled with ^{51}Cr and ^{113m}In-transferrin complex (*10–12*). One of these, ^{113m}In, is a short-lived metastable isotope with a half-life of 1.7 hr and a single gamma ray of 393 keV. It is obtained by "milking" a ^{113}Sn generator which has a half-life of 118 days. Because of its short half-life, millicurie quantities of ^{113m}In can be administered to patients without exceeding acceptable radiation doses to internal organs. When injected intravenously at pH 4 or less, ^{113m}In attaches to transferrin or a transferrin-like protein at an unfilled iron binding site. This complex circulates throughout the blood including the placenta with very little transfer across the placenta to the fetus. The urinary excretion is so low (0.06–0.1% of administered dose) (*11*) that bladder activity is not confused with placenta previa as may happen with ^{99m}Tc-albumin. Circulating biological half-time of the indium transferrin complex is 3 hr, resulting in an effective half-time of nearly 1 hr which allows sufficient time for counting or scanning.

The first isotopic methods used in placental localization were not very accurate. With these methods, a collimated scintillation detector was positioned above 9–15 sites selected arbitrarily on the maternal abdomen. The counting rate above each site reflected roughly the distribution of activity within the abdomen and was highest over the placenta. Short-lived isotopes introduced recently (^{99m}Tc and ^{113m}In) may be administered in higher quantities, permitting scans to be made of the maternal abdomen. The distribution of activity is visualized more clearly by scanning than by the counting-rate method. This paper is a report of 16 ^{113m}In placenta scans.

ANIMAL EXPERIENCE

Five hundred microcuries of ^{113m}In were administered intravenously to a term pregnant mongrel dog, and a cesarean section was performed 45 min later. Uncontaminated amniotic fluid was obtained. The dog, whelps and placentas were analyzed for percent deposition of ^{113m}In in the whole-body counting facility of the Colorado Department of Public Health. Activity in the amniotic fluid was measured in a well counter with a 3-in. NaI(Tl) crystal. All counts were corrected for decay and background. These results are tabulated in Table 1. The data indicate very little placental transfer of the ^{113m}In.

DOSE CALCULATIONS

The dose of radiation delivered to the human fetus during placenta scanning was calculated assuming the uterus and placenta are approximated by the geometry depicted in Fig. 1 (*13*). The total blood volume of the mother was estimated to be 5,250 ml with 250 ml in the intervillous space of the placenta. The total uterine blood volume was estimated to be 1,000 ml. The average uterine radius was estimated to be 13 cm and the placenta radius 8 cm (*14*). An equation was derived (*13*) for the energy flux from primary gammas and fluorescence x-rays at an arbitrary point P on the diameter of a spherical shell (uterus). The spherical shell was assumed to possess

Received Jan. 8, 1969; revision accepted July 10, 1969.

For reprints contact: Donald W. Brown, University of Colorado Medical Center, 4200 E. Ninth Ave., Denver, Colo. 80220.

TABLE 1. ACTIVITY DEPOSITION 45 MIN AFTER 500 μCi ^{113m}In ADMINISTRATION TO TERM PREGNANT MONGREL DOG CORRECTED FOR DECAY AND BACKGROUND

	Total activity deposited (%)
Dog with whelp (before C-section)	100.0
Placenta	2.5
Amniotic fluid	0.0097
Whelp	0.0044

TABLE 2. SUMMARY OF THE 16 CASES REPORTED

Patient	Diagnosis rendered: Ultrasound scan	Diagnosis rendered: Radionuclide scan	Proof
1	Partial placenta previa	Low right posterior	Partial marginal rupture, vaginal delivery
2	Partial placenta previa	No placenta previa	Normal placenta, vaginal delivery
3	Partial placenta previa	Low anterior	50% placenta previa, cesarean section
4	Low lying placenta	Placenta previa	Central placenta previa, cesarean section
5	Partial placenta previa	No placenta previa, left lateral	Normal placenta, vaginal delivery
6	Partial placenta previa	No placenta previa, high right ant.	Normal placenta, vaginal delivery
7	——	No placenta previa, low anterior	Normal placenta, vaginal delivery
8	Low lying placenta	No placenta previa, right lateral	Normal placenta, vaginal delivery
9	Marginal placenta previa	Placenta previa, low right	Placenta previa, cesarean section
10	Left low anterior	No placenta previa, left lateral	Abruptio placenta, cesarean section
11	Complete placenta previa	Placenta previa centralis	Total placenta previa, cesarean section
12	Right anterior lateral	Upper right anterior	Normal placenta, vaginal delivery
13	Left anterior lateral	Left anterior lateral	Partial abruptio, vaginal delivery
14	Left anterior lateral	Left anterior lateral	Normal placenta, vaginal delivery
15	Left anterior	Left anterior	Normal placenta, vaginal delivery
16	Partial placenta previa	Left anterior high	Normal placenta, vaginal delivery

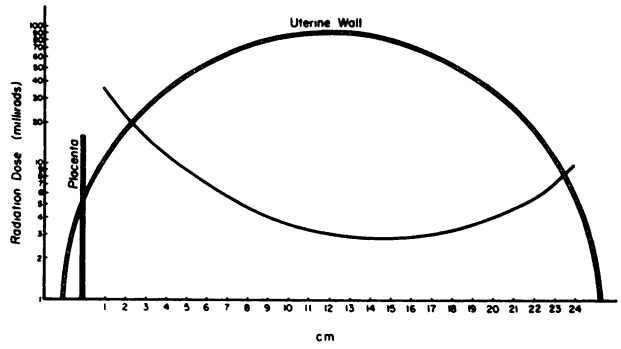

FIG. 1. Geometry assumed for calculation of radiation dose along axis through center of uterus. Dose in millirads is plotted as function of distance in centimeters (horizontal axis) along diameter of uterus which intersects center of placenta at right angle.

TABLE 3. SUMMARY

Total cases	16
Placenta previa	4 (all proven by cesarean section)

	Ultrasound scan	Radionuclide scan
Diagnosis incorrect	5	1
Diagnosis correct	10	15
Accuracy (%)	67	94

uniform activity distributed upon the surface. A second equation was derived for the energy flux from primary gammas and fluorescence x-rays at an arbitrary point on the axis of a thin disk source (placenta). The disk was also assumed to possess uniform activity distributed upon its surface. An expression was then derived for the dose rate in millirads/second at a point due to primary photons and fluorescence x-rays from a disk source with uniform activity positioned within a spherical shell with uniform activity. Assuming immediate uptake and no biological elimination for 1 mCi of ^{113m}In given intravenously, the total dose in millirads was calculated at 1-cm intervals along the diameter of the sphere which intersected the center of the disk at a right angle. As may be seen from Fig. 1, the total dose 1 cm from the placenta is 36 mrads, falling to 3 mrads 14 cm away. These data include correction for attenuation of the radiation by interposed soft tissue.

Exposures to the fetus during a pelvimetry examination can range up to 100 mR per film, depending on technique (*15*). Exposures to the gonads during a pelvimetry examination range from 400 to 2,500 mR (*11*). Comparison of these doses with the results of our calculations substantiate our previous assumption that the fetus receives far less radiation dose from a placenta scan with ^{113m}In than from a roentgenographic pelvimetry examination.

METHOD

Indium-113m from a tin-indium generator has a pH of 1.5. Ten percent gelatin and NaCl are added and sterilization obtained by Millipore filtration (0.22 micron). One millicurie of ^{113m}In was given intravenously to the patient. Scanning was done in the supine and lateral projections using a 5-in. rectilinear scanner. The time required for scanning with this scanner was 2–3 hr. Since the scans reported here, we have used a 10-crystal scanner which reduces this time to 45–60 min.

RESULTS

From October 18, 1967 to July 3, 1968, 16 radioisotope scans were performed at the University

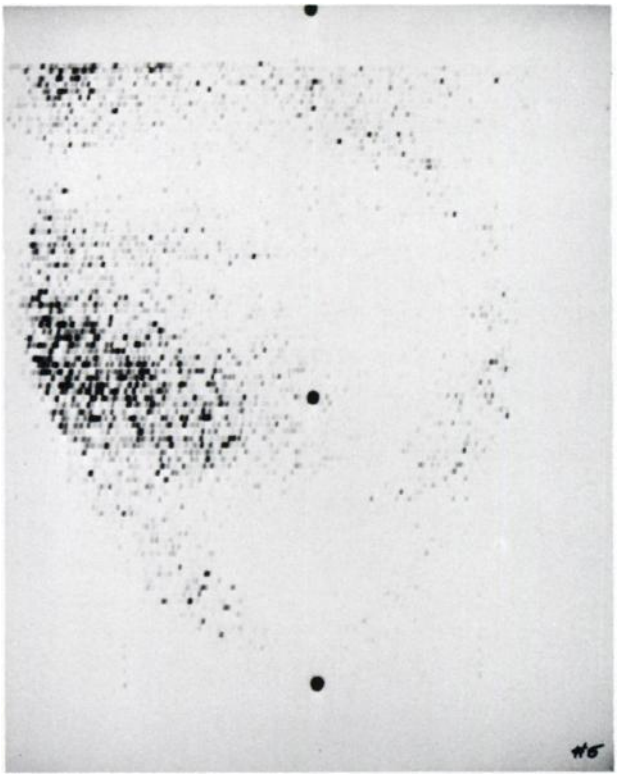

FIG. 2. AP scan of patient with central placenta previa proven at C-section. Upper dot is xyphoid; lower is pubic symphysis.

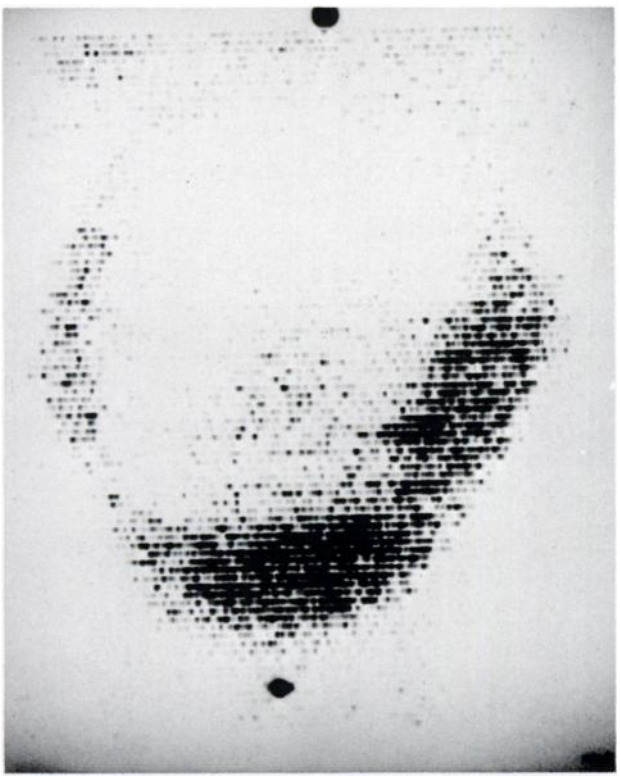

FIG. 3. AP scan of patient with central placenta previa Upper dot is umbilicus; lower is pubic symphysis.

of Colorado Medical Center using ^{113m}In. All scans were interpretable. Ultrasound scans were done in 15 of the 16. The nuclide and ultrasound scans were correlated with cesarean sections and clinical impressions during vaginal delivery. The placenta was localized in all the scans (see Table 2).

The interpretation of the isotope scans was correct in all cases but one (Patient No. 3, Table 2), a 50% placenta previa proven at cesarean section. The radioisotope scan diagnosis was "placenta anterior lower 1/3, may be near the internal os but no definite evidence of placenta previa." The ultrasound diagnosis was "partial placenta previa." In retrospect, the radioisotope scan should have been interpreted as suggestive of a partial placenta previa. The numbers and types of cases are summarized in Table 3.

Figure 2 shows an ^{113m}In scan done on a 24-year-old woman (Patient No. 4, Table 2) at 36 weeks gestation and read as "inferior left lateral placenta compatible with placenta previa." A cesarean section was done and a central placental previa found. Figure 3 shows a scan (Patient No. 2, Table 2) described as a normal high right anterior placenta without evidence of placenta previa. The patient had a normal vaginal delivery.

Some activity is normally seen in the liver and in the urinary bladder. The uterine wall and pelvic vessels sometimes are seen. To locate the placenta accurately, it is necessary to indicate on the scan certain anatomic points such as the umbilicus, pubic symphysis, xyphoid and anterior superior iliac spines. Activity in the liver and bladder is distinguishable from activity in the placenta.

SUMMARY

Placenta scanning using ^{113m}In-transferrin complex was performed in 16 patients. All but one of the scans were correctly interpreted. The radiation dose to the mother is minimal and to the fetus even less, both well below acceptable limits. The method is safe, accurate, painless and relatively simple to perform.

ACKNOWLEDGMENT

This project was supported by National Heart Institute research grant HE-09112 and AEC Research Contract AT (11-1)1472.

REFERENCES

1. GOTTESFELD, K. R. *et al:* Ultrasonic placentography—a new method for placental localization. *Am. J. Obstet. Gynecol.* **96**:538, 1966.

2. BIRNBAUM, S. J. AND KLIOT, D. A.: Thermoplacen-

tography: placental localization by infrared sensing techniques. *Obstet. Gynecol.* **25**:515, 1965.

3. CAVANAGH, D., POWE, C. E. AND GILSON, A. J.: Placenta previa: modern methods of diagnosis with special reference to isotopic placentography. *Obstet. Gynecol.* **18**: 403, 1961.

4. PAUL, J. D., JR. *et al:* Placenta localization using Cr^{51} tagged erythrocytes. *Obstet. Gynecol.* **21**:33, 1963.

5. WEINBERG, A. *et al:* Localization of the placental site by radioactive isotope. *Obstet. Gynecol.* **9**:692, 1957.

6. VISSCHER, R. D. AND BAKER, W. S., JR.: Isotope localization of the placenta in suspected cases of placenta previa. *Am. J. Obstet. Gynecol.* **80**:1,154, 1960.

7. COOPER, R. D. *et al:* Isotopic placentography or placental scanning? *Radiology* **87**:291, 1966.

8. KLEIN, E. W. AND HOPWOOD, H. G.: Isotope localization and scanning of the placenta. *Am. J. Roentgenol.* **94**: 844, 1965.

9. MCAFEE, J. G. *et al:* 99m-Tc labeled serum albumin for scintillation scanning of the placenta. *J. Nucl. Med.* **5**:936, 1964.

10. STERN, H. S. *et al:* In^{113m} for blood-pool and brain scanning. *Nucleonics* **25**:No. 2, 62, 1967.

11. WAGNER, H. N.: *Principles of Nuclear Medicine,* W. B. Saunders Co., Philadelphia, 1968.

12. MISHKIN, F. *et al:* Placental localization by scanning with ^{113m}In (abstr.). *J. Nucl. Med.* **9**:336, 1968.

13. HENDEE, W. R. AND NIEHOFF, R. D.: Radiation dose to the fetus during placenta scanning. *J. Nucl. Med.,* in press.

14. EASTMAN, N. J.: *Williams Obstetrics,* 11th ed., Appleton-Century-Crofts, Inc., New York, 1956.

15. LAUGHLIN, J. S. *et al:* Bone, skin and gonadal doses in routine diagnostic procedures. *Am. J. Roentgenol.* **78**: 961, 1957.